A Propose Architecture of MANET for Disaster Area Architecture

R.P.Mahapatra, Tanvir Ahmad Abbasi, and Mohd Suhaib Abbasi

***Abstract*—Wireless ad hoc networks have become an important area of research in wire-less communications systems. Unlike some existing networking technologies such as Internet Protocol (IP) networks or cellular systems, wireless ad hoc networks have the advantage that deployment of networks does not require preexisting infrastructures. Ad hoc networks have neither fixed topology nor centralized servers; it is assumed that, once deployed, the network nodes would self-configure to provide connectivity and form a communications network. Communications are vital for effective management and execution of disaster response and recovery efforts emergency response personnel must be able to exchange information with each other from anywhere, at any time, to successfully fulfill their missions. The National Communications System (NCS) has initiated an effort to improve communication capabilities by first identifying the full range of communication requirements within the disaster area. The NCS has interviewed disaster response managers with experience in the most recent occurrences, to learn specific communication and information system requirements are most critical. A Disaster Area Architecture was designed to meet these requirements. The so-called emergency communications at the time of catastrophic disaster etc. is considered to use ad hoc network effectively. Therefore, it is important to configure emergency communications networks that offer required sufficient QOS in disaster conditions using ad hoc networks. We arrange information and communication required after a disaster from the viewpoint of time elapsed since the disaster. We propose a possible practical communication model for developing ad hoc network configuration technologies.**

***Index Terms*—Disaster Area Architecture (DAA), Emergency Communication (EC), Mobile ADHOC Network (MANET), Practical Communication Model (PCM)**

I. Introduction

A general mobile network consists of wireless access networks and interconnecting backbone networks. The mobile terminals are connected to the base stations (access points) by wireless access networks, and the base stations are connected to the wired backbone networks. There are drawbacks to these systems when large-scale disasters, such as earthquakes, occur: if the base stations or other elements of the infrastructure comprising these networks are damaged by disasters, communications may be impossible.[2]

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Even if the infrastructure is not damaged, spikes in traffic and congestion may render communication virtually impossible.

It is essential to restore communication networks in large-scale disasters by repairing the infrastructure as quickly as possible and taking appropriate measures to control congestion. Communication and sharing of information in emergencies are also possible via ad hoc networks, which take full advantage of the features of wireless communication[14] including rapid and temporary setup and outstanding terminal portability and mobility. Ad hoc networks can enable communication among temporarily assembled user terminals without relying on the conventional communication infrastructure.

Therefore, it is important to configure a communication network that offers sufficient QoS after a catastrophic disaster using an ad hoc network to help protect people. In this paper, we categorized the information and communication required after a disaster from the viewpoint of time elapsed since the onset of the disaster.[7] We propose a practical and suitable communication model for developing ad hoc network configuration technologies required in order to realize such communications.

We evaluated the performance of ad hoc networks by simulating two practical scenarios using this model. The purpose of the Disaster Area Architecture (DAA) effort is to improve information exchange and facilitate coordination among: Emergency Support Function (ESF) managers; FEMA national and regional offices and the Disaster Field Office (DFO); State/local entities; and private industry. This is accomplished through the integration of existing information systems, implementation of new, efficient technologies, and interconnection of established networks. This architecture improves information access and exchange between Federal, State and local agencies thereby enhancing their disaster recovery and response efforts.

II. Information And Communication Required At The Time Of Disaster

There are two types of catastrophic disasters; natural phenomena, such as an earthquakes, tsunamis, and floods, and artificial phenomena such as war and terrorism. Here, we mainly focus on sudden natural disasters, such as an earthquake.[5] Different response measures and information are appropriate depending on the amount of time elapsed since the onset of the disaster. The purposes, sources and destinations, and content of communications and of dissemination of the information when a disaster occurs are classified for each place where transmission and reception are needed are shown in Table 2.

The ad hoc (non infrastructure) network is actively used in the communications listed in the cells framed by black lines is used cooperatively with the existing network's infrastructure in the communications listed in the cells framed by gray lines. The network infrastructure is used mainly in the communications listed in the cells framed by white lines. It is necessary to set up more practical and suitable communication models for each of these required communications and to develop the ad hoc network configuration technologies to develop communications based on these models

ESF	Organization	Function	Function Description
1	DOT	Transportation	Provide for the coordination of Federal transportation support to State and local governmental entities, voluntary organizations, and Federal agencies requiring transportation capacity to perform disaster assistance missions
2	OSTP	Communications	Assure the provision of Federal telecommunications support to Federal, State, and local response efforts
3	DoD	Public Works and Engineering	Provide public works and engineering support to assist the State(s) in needs of lifesaving of life protecting
4	USDA	Fire Fighting	Detect and suppress wildland, rural, and urban fires resulting from, or occurring coincidentally with, a catastrophic
5	FEMA	Information Planning	Collect, analyze, and process critical information; compile the information into reports and displays; and develop action plans to facilitate the overall response operations of the Federal government
6	Am. Red Cross	Mass Care	Coordinate efforts to provide sheltering, feeding, and emergency first aid; collect and report information about the status of victims and assist with family reunification; and coordinate bulk distribution of relief supplies to disaster victims
7	GSA	Resource Support (Logistics)	Provide logistical and resource support
8	HHS	Health and Medical Services	Provide U.S. Government coordinated assistance to supplement State and local resources in response to public health and medical care needs
9	FEMA	Urban Search and Rescue	Provide immediate disaster response including searching for, extricating and applying medical treatment to victims trapped in collapsed structures
10	EPA	Hazardous Material	Provide Federal support to state and local governments in response to an actual or potential discharge and/or release of hazardous material
11	USDA	Food	Identify, secure, and arrange for the transportation of food assistance to affected areas
12	DOE	Energy	Facilitate restoration of the nation's energy systems

Exhibit 1 - ESP Responsibilities under the Federal Response Plan

III. Disaster Area Architecture

In accordance with the FRP, disaster response and recovery is divided into 12 functional areas, or ESFs: 10 primary ESFs and 2 support ESFs. ESF2, Communications, is responsible for providing communication capabilities to the other ESFs.

The ESFs are the primary mechanism to provide Federal response assistance to State and local response and recovery activities during a Federally declared disaster. Federal disasters are declared by the President, through the invocation of the Stafford Act1, based on a State request.[18] Exhibit 1 shows ESF organizations and their primary responsibilities. Prior to the formal activation of the ESFs, the lead officer for the disaster response and recovery effort, the Federal Coordinating Officer (FCO), along with the ESF managers, leads the Emergency Response Team (ERT).

The ERT staffs the DFO to provide administrative, logistic, and operational support to field response activities. The DFO is the primary facility in each affected state for the coordination of response and recovery operations and is typically located on the fringe of the disaster area. The DFO is established as soon as possible, but often takes from three to seven days to become fully operational. Once operational, the DFO assumes operational control of the support effort from the FEMA Regional Operations Center (ROC).

The DFO becomes the hub for all Federal relief activities in the disaster area. DFO staff can vary in size, from 100 to 3000, depending on the scale of the response, the number of DFOs established, and the DFO function. ESFs that conduct emergency operations similar to their normal day-to-day functions typically do not center operations out of the DFO.[18] Instead they use regional locations to conduct operations.

Communication requirements among regional locations and the DFO, at a minimum, consist of receiving and responding to assignments, providing status, and ensuring DFO ESFs access to all disaster response information. This places considerable importance in reliable and assured communications among regional elements that may be affected by regional congestion and infrastructure damage. ESFs that base operations out of the DFO have significant communication needs that require ESF2 to provide or increase existing capabilities to meet those requirements. The majority of communication requirements are intra-ESF; however, communications must be maintained among ESFs that respond to field situations and between the ESFs and FEMA.

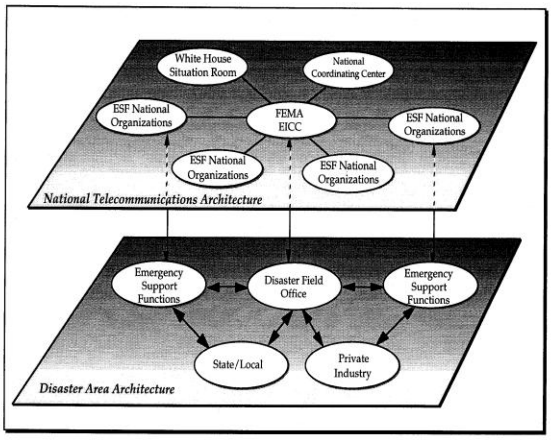

Exhibit 2 - Architecture Concept

Emergency users described real-time voice capabilities as vital to operations for rapid assessment and decision making. In addition, data communication capabilities are required to support the operational analyses of disaster response. Data services, as they become available, are increasingly important for disaster recovery and response. Examples include the transmission of personal medical files for the injured, or geographic information system (GIS) information on the local environment, and other data base information.[6] An architecture that addresses these needs is necessary to facilitate or enable information exchange in the disaster area. Exhibit 2 shows the architecture concept for national and disaster area communications.

The national level architecture is fixed in nature, allowing headquarters organizations and national centers to be linked via high-speed circuits on a permanent basis. Initiatives to share information among these organizational entities are ongoing - as organizations learn what is available and develop agreements and partnerships to share (and protect) information.

The vertical architecture represents the agency infrastructure used to support regional offices or deployed personnel in the field. These can be supported by both fixed and mobile assets. For example, the National Disaster

Medical System (NDMS) is a vertically integrated communications capability developed specifically to support ESF 8 - Health and Medical Services. It comprises national and regional office networks as well as "fly-away" kits with suites of communications equipment (cellular telephones, laptops, pagers, etc). The disaster area architecture seeks to provide communications capabilities and interoperability among all the ESFs in the disaster area, state/local government, and accede grew to national level resources. At the hub of activity in the disaster area is the DFO,[17] which provides much of the communications and coordination among agencies.

IV. Shortfalls & Enhancements

Voice is the single most important means of communications for emergency response personnel. It supports real-time coordination in emergencies. However, inadequate directory services and network congestion limit the effectiveness of voice in the disaster area. A stable set of emergency response phone numbers and an immediate, automated telephone directory for an affected region can provide more streamlined response. Advanced Intelligent Network (AIN) features also show promise in rediverting and directing calls to their appropriate destinations. An inability to place or complete a call on the network due to network overload and congestion has plagued emergency response.

Wire line carriers will often block traffic coming into a region to allow better call completion for those calling out of the affected area. (GETS) offer users at any telephone to dial a special telephone number and personal identification number (PIN) and circumvent carrier network management and controls. Cellular networks in an affected region have experienced an increase in offered traffic between 300 to 1000 percent.

Identified Need	Description
Improved voice services	• Voice conferencing and telephone number portability • Simplified dialing schemes for wireline voice enhancements • Circumvent wireline and wireless congestion • Simplified access (e.g., dialing requirements) to wireline and wireless augmentations
Messaging among ESFs and regional elements	• Ability to send, receive and read e-mail messages with attachments within and among the ESFs in the DFO, including via Internet • Connectivity for e-mail capabilities between the DFO and agency offices through agency networks and Internet • User friendly directory services • Ability to address messages to and from deployed locations
Information access and sharing	• User friendly electronic capability for intra-DFO messaging, sharing of ESF requirements, disaster response information and capabilities, and SitReps • Capability to access, read and/or manipulate distributed databases containing disaster response information, including read only files
Improved and streamlined service provisioning	• Greater distribution of wireless devices including pagers, satellite terminals, cellular phones programmed to local phone numbers (with data ports, as needed) • Greater distribution of fax machines (with analog compatibility) • Connection and routing augmentations among regional elements • Dial-up capabilities to DFO • Internet access
Disaster area frequency management	• Single system to distribute and manage ESF radio frequencies to mitigate interference, including the documentation of used frequencies to allow for easier inter-ESF wireless communications

Exhibit 3 -Communications Shortfalls

New programs such as Cellular Priority Access Service (CPAS) promise to recognize and provide priority treatment to cellular NS/EP users to bypass local congestion. Electronic messaging is also a key element of disaster area communications [6]. However, it is hampered by inconsistent implementation, interoperability limitations, and access to ESF agency networks. Different software standards among ESF organizations, differences in accessibility among agency networks, and availability and use of the Internet are among the challenges facing successful e-mail implementation.

Prescribing a standard e-mail software solves many of the problems with e-mail among ESF organizations at the DFO. However, this requires users to use software that may be different than their home office. In addition, it may be incompatible with their home office. As government-wide e-mail programs emerge and X.400 standards are adopted,[14] these problems should be minimized. Unless agency networks allow a dial-up capability, accessing agency networks from the DFO can also be difficult. The Internet has been used to bridge these gaps, but can often be congested (or even physically damaged) as a result of the disaster. In addition, the Internet is not engineered to support low-delay, guaranteed delivery of messages. In one instance, it took over 6 hours for an e-mail to reach its destination - not very promising in an environment which requires immediate response. Access to agency networks via dedicated lines or through the FEMA network (which in turn can be linked to agency networks) should provide the required connectivity. Information sharing is one of the primary purposes of the DFO [18]. To date, much of the information sharing is accomplished through personal interaction, through paper, or not at all.

Electronic information sharing is often not available or difficult, due to lack of computers, insufficient Local Area Network (LAN) ports, unknown addresses, or incompatible software. More computers, more LAN ports, consistent addressing (or directories) and interoperable software can mitigate many of these problems. In addition, shared services and bulletin boards offer a means to post or retrieve common information or ask questions to all or selected response personnel.

One of the essential activities in emergency response is rapid and effective service provisioning. Ensuring NS/EP users have the right equipment, network access, and information resources in the disaster area is essential. Today, many of the ESFs provide for themselves or rely on FEMA and GSA deployed equipment for computing and communications. This is often not coordinated until users reach the DFO. This often results in insufficient computing and telephone resources (for those coming without equipment), inadequate LAN or telephone ports (for those coming with equipment), and limited access to remote network resources, other than those available through dial-up and the FEMA LAN/WAN. Much of the provisioning is accomplished real-time, leveraging extensive government and industry relationships that have been developed over time. In addition, the Telecommunications Service Priority (TSP) program authorizes the priority provisioning and restoration of NS/EP telecommunications services [7].

Much of the service provisioning can be planned in advance. An automated capability could capture and learn from similar disasters in a particular region. It could match needed resources against ESF equipment that maybe stored locally or included in fly-away kits. In this manner, the appropriate LAN and PBX ports could be set-up in advance [3]. Unmet requirements could be linked to automatically look-up

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contacts (government and industry) to order the equipment or service. Finally, radio communications is one of the most valuable services deployed. However, the more complex the response, the more coordination is necessary. Radio users must avoid interference on common channels and be able to quickly locate users on specified channels, particularly those native to the disaster area. Frequency management, a means to organize, assign, and locate frequencies, is essential to organized disaster response.

The Forest Service, at the request of FEMA, is working to develop a system that will automate and coordinate the use of radio frequencies in the field. The disaster area architecture was developed to help crystallize and capture information requirements for ESF managers in the field. The benefits of the study include building an understanding of the common problems faced by various ESFs, sharing solutions and best practices to specific problems, and defining improvements that can help ESFs to successfully

V. Conclusion

We have investigated post-disaster communication from the viewpoint of time elapsed and classified communication based on purpose, sources and destinations, and contents of communications for each transmitter and receive.

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